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(54) **METHOD FOR TRANSFERRING A LAYER FROM A DONOR SUBSTRATE ONTO A HANDLE SUBSTRATE**

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USPC ..... 438/458  
See application file for complete search history.

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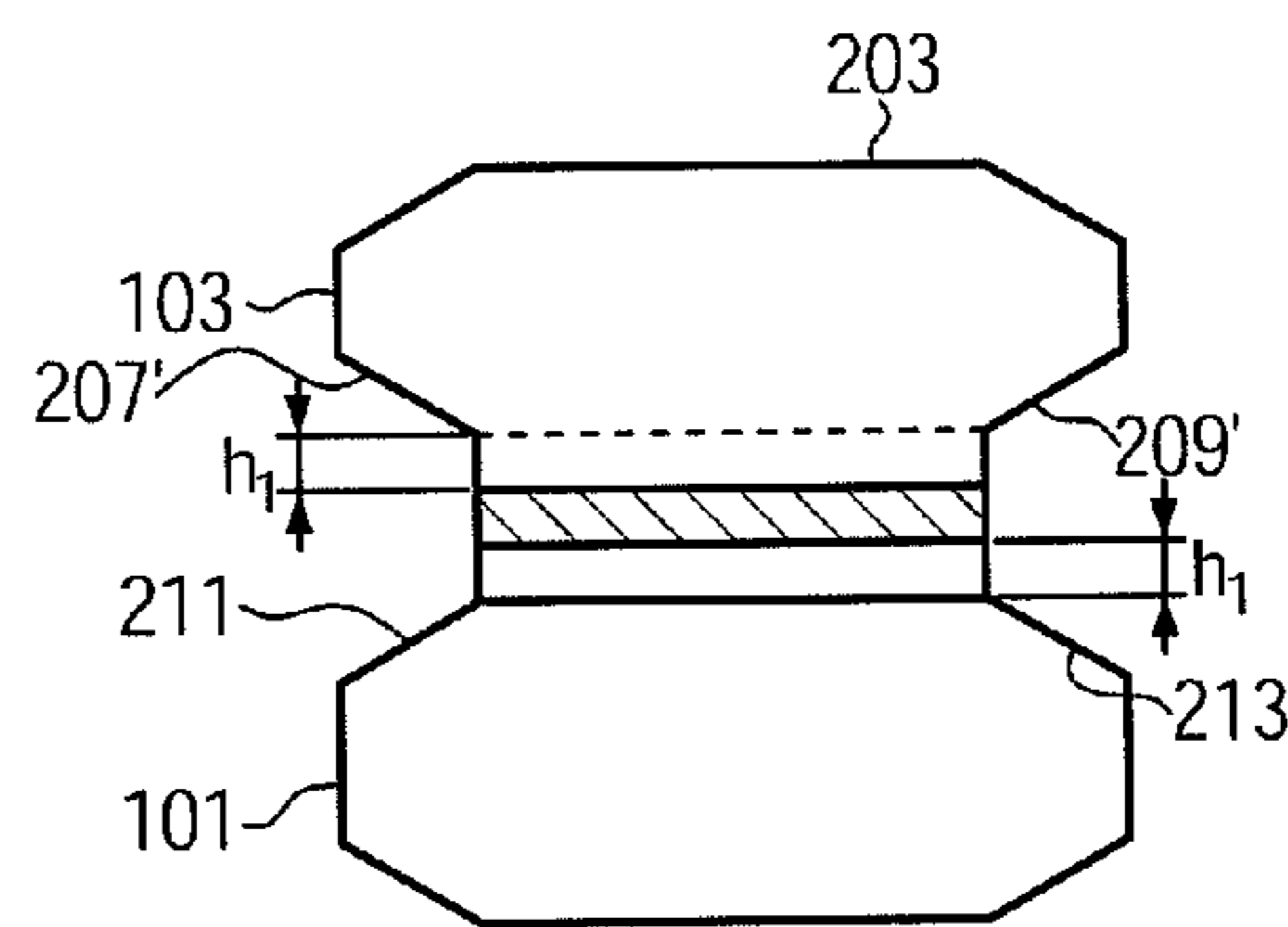
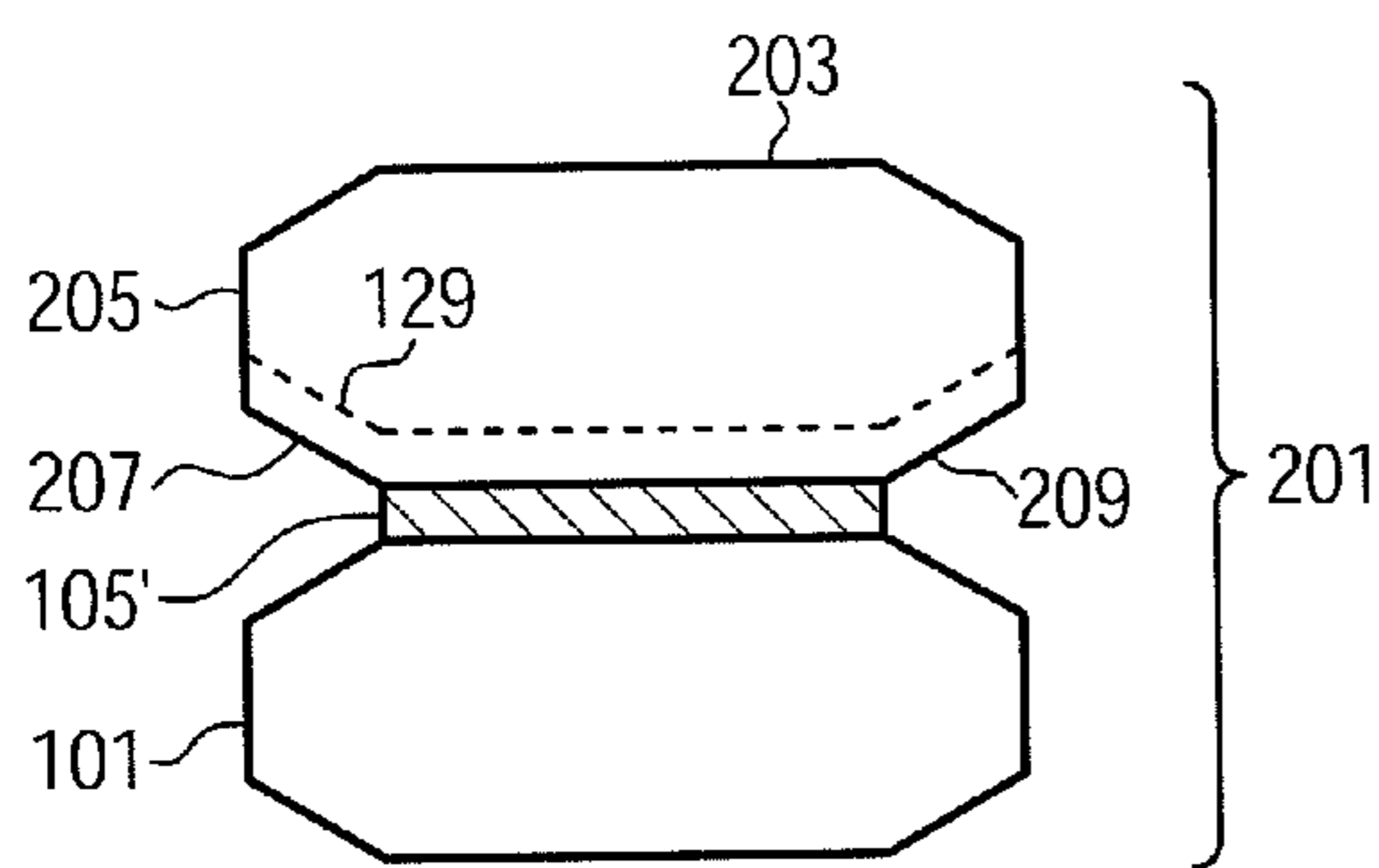
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(57) **ABSTRACT**

The invention relates to a method for transferring a layer from a donor substrate onto a handle substrate wherein, after detachment, the remainder of the donor substrate is reused. To get rid of undesired protruding edge regions which are due to the chamfered geometry of the substrates, the invention proposes to carry out an additional etching process before detachment occurs.

**20 Claims, 4 Drawing Sheets**



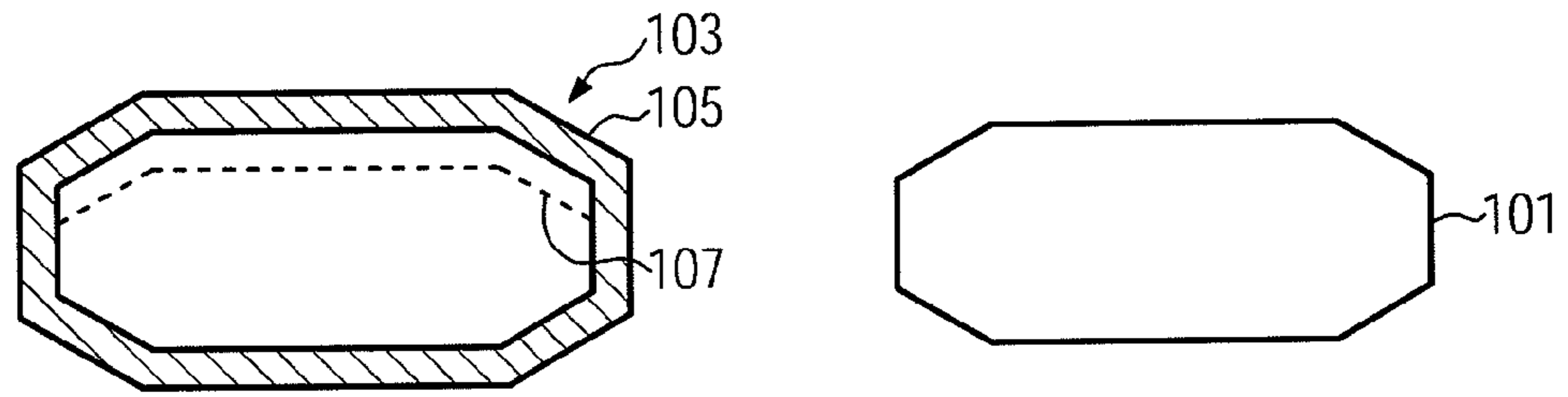


FIG. 1a

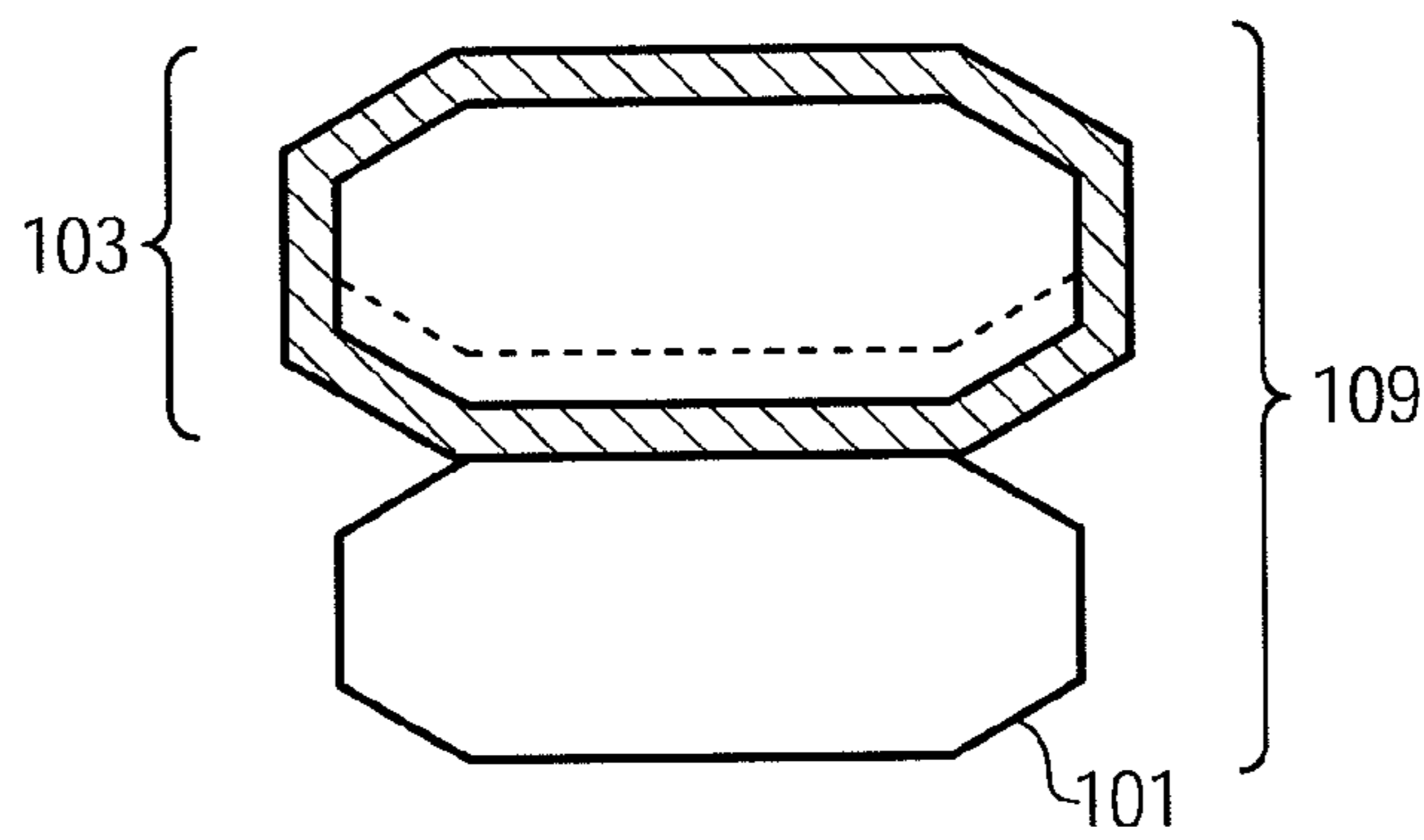


FIG. 1b

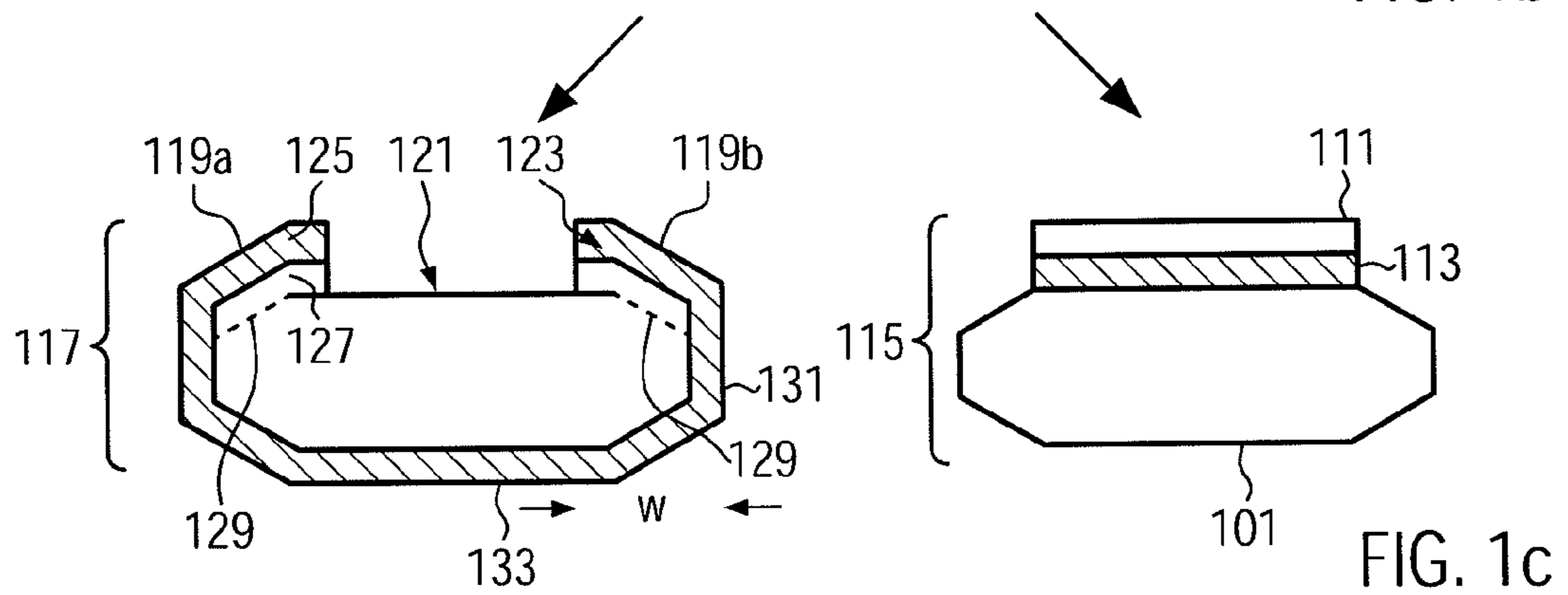
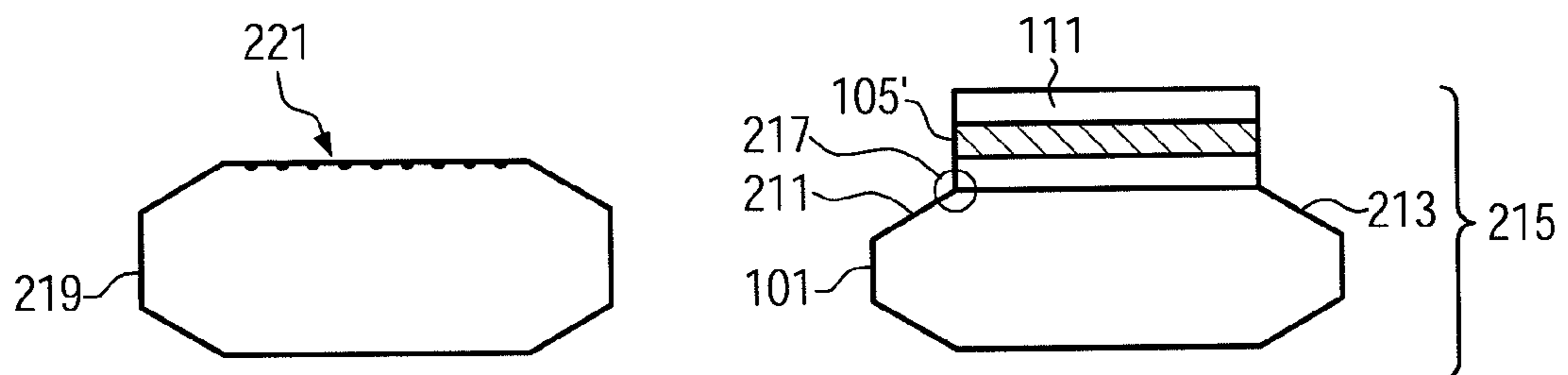
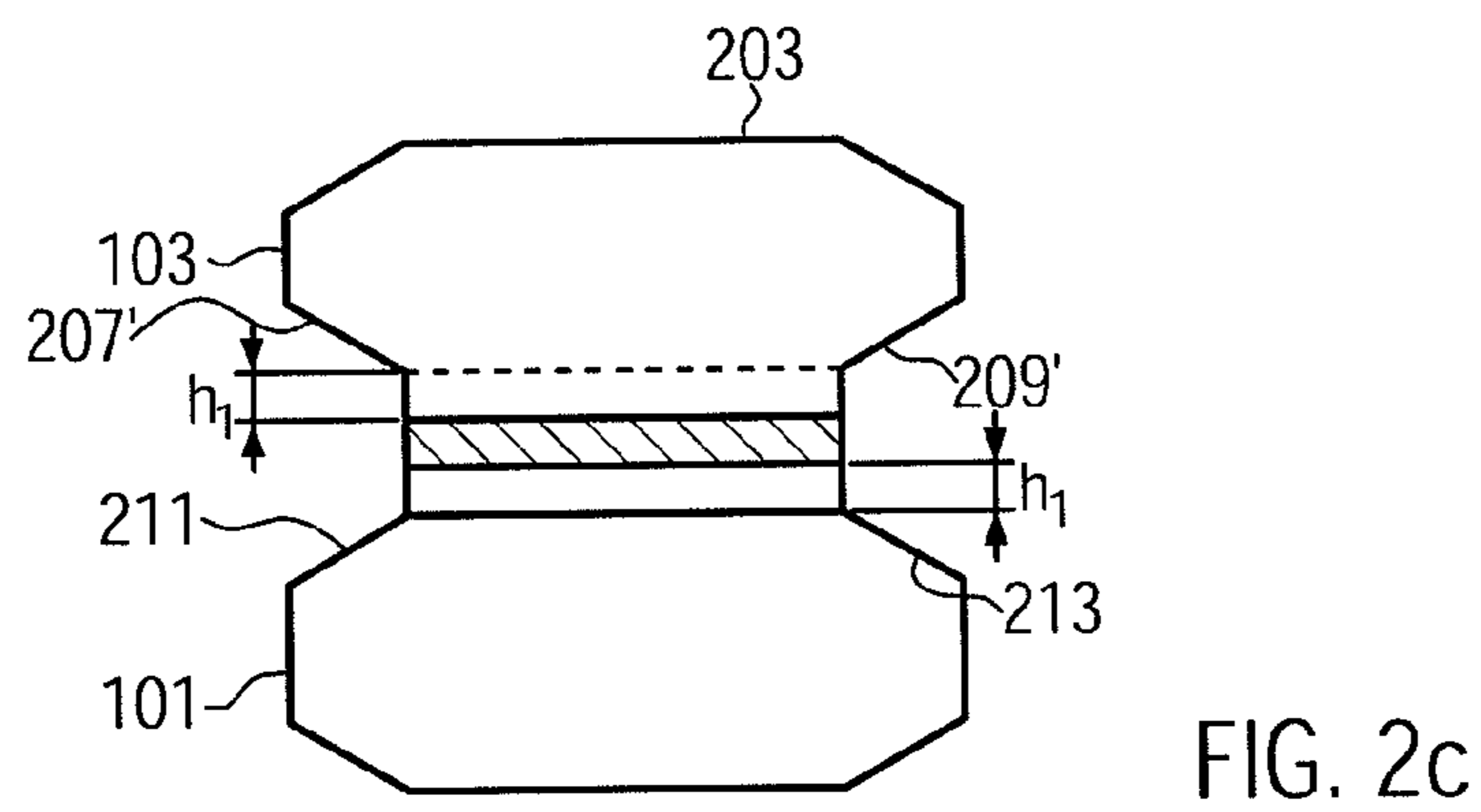
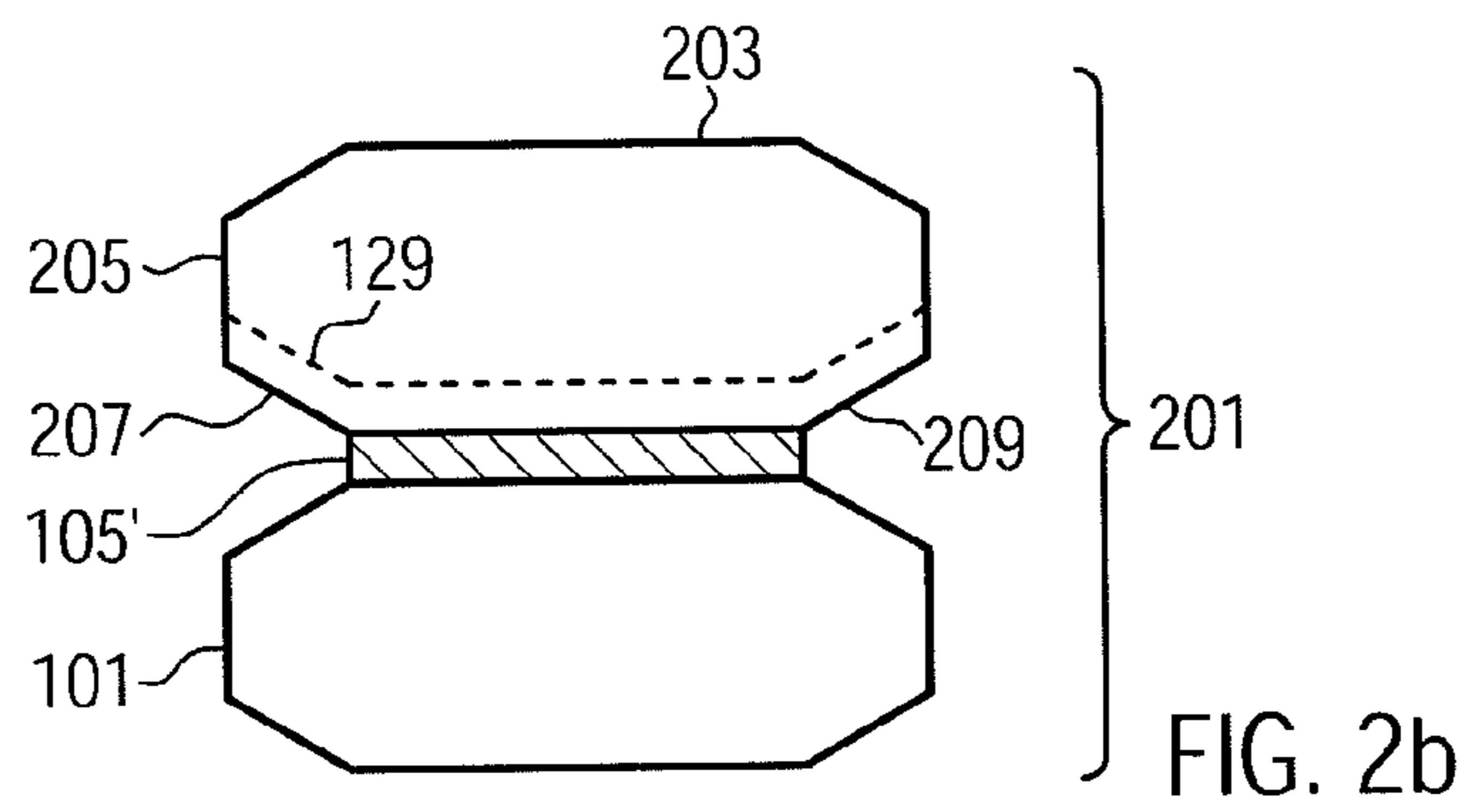
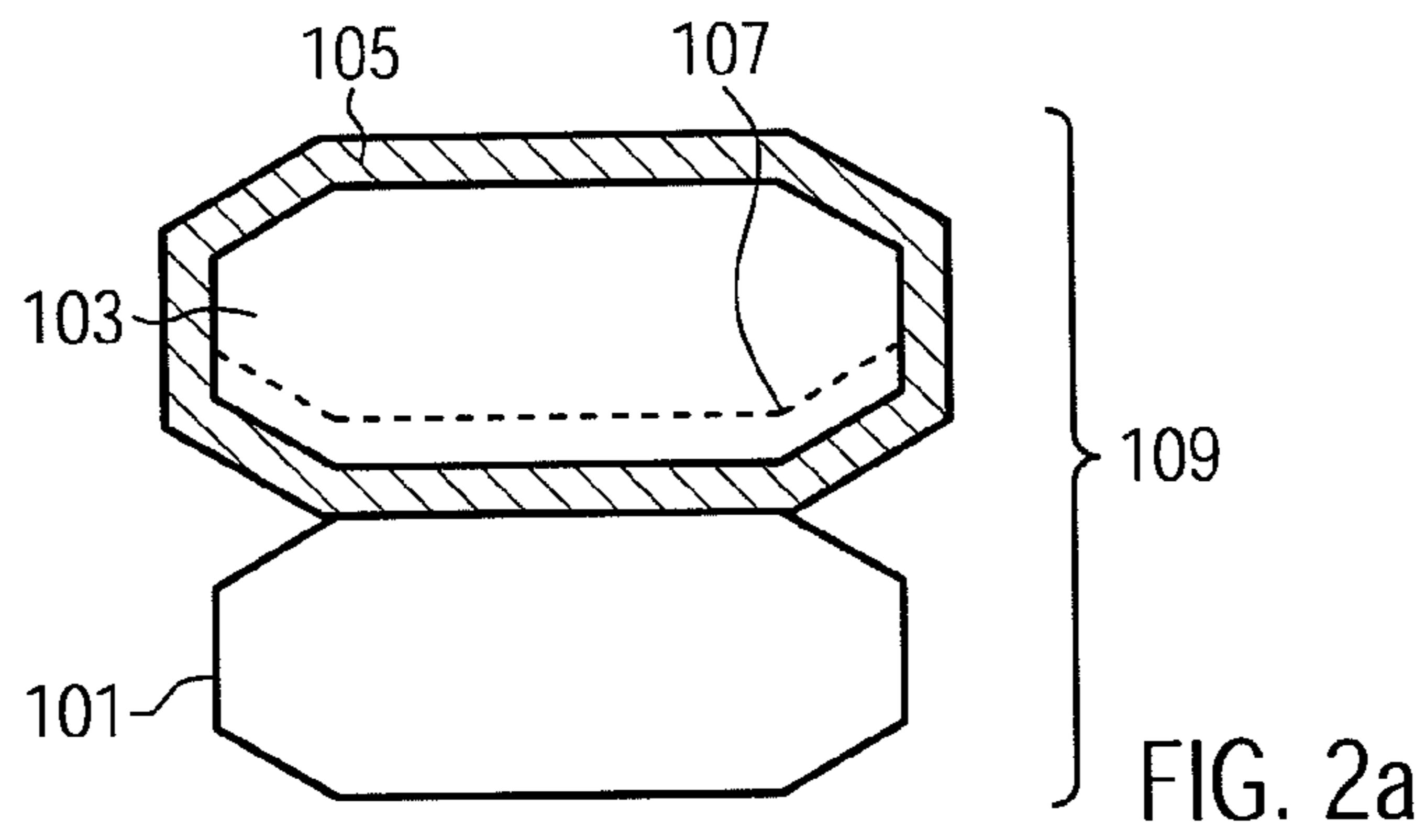
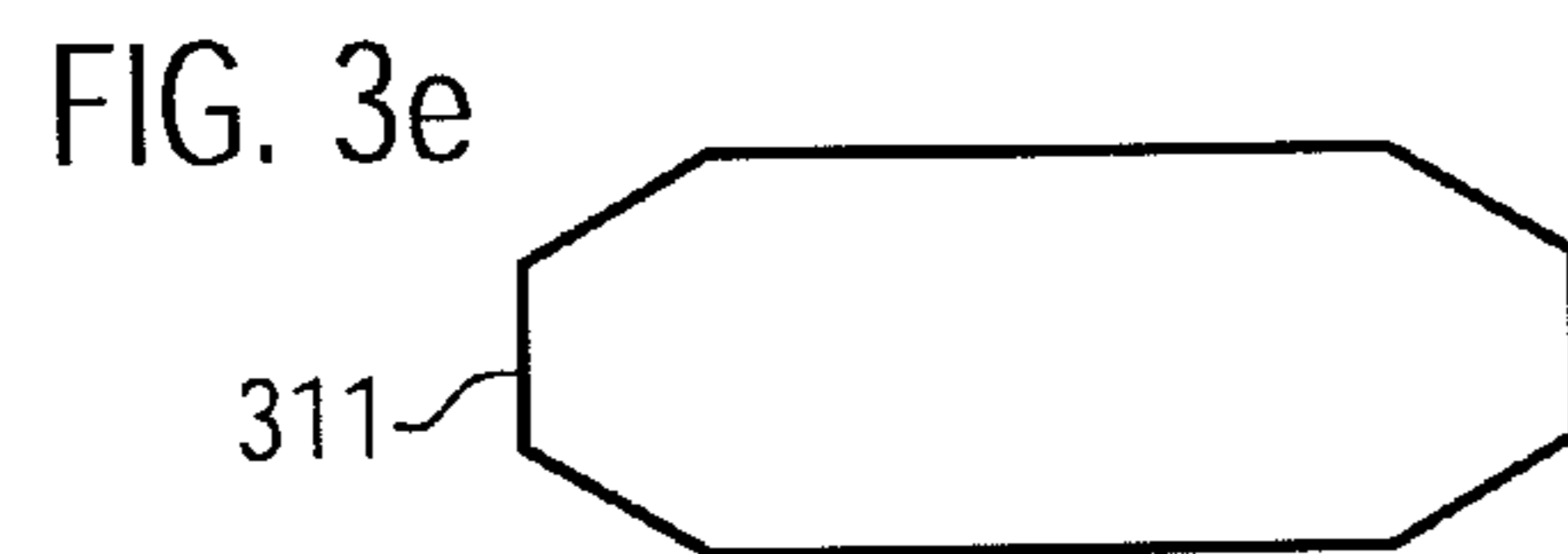
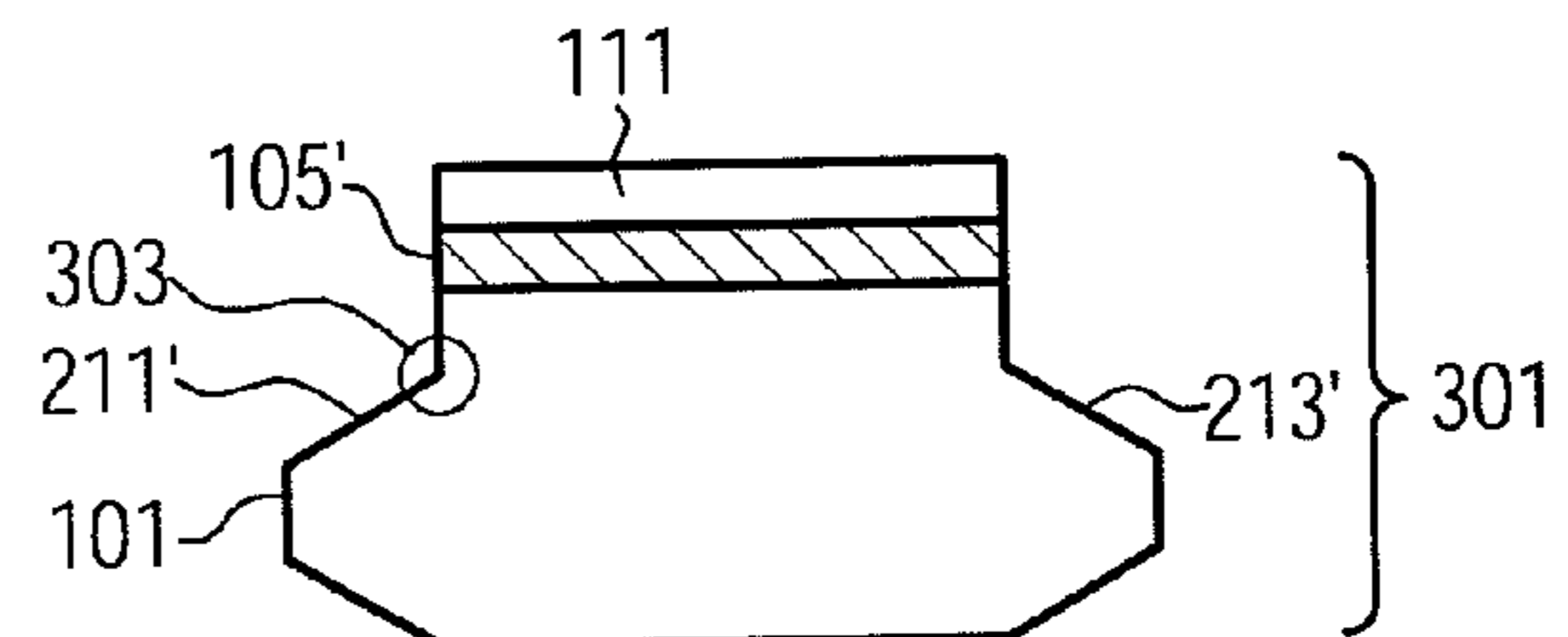
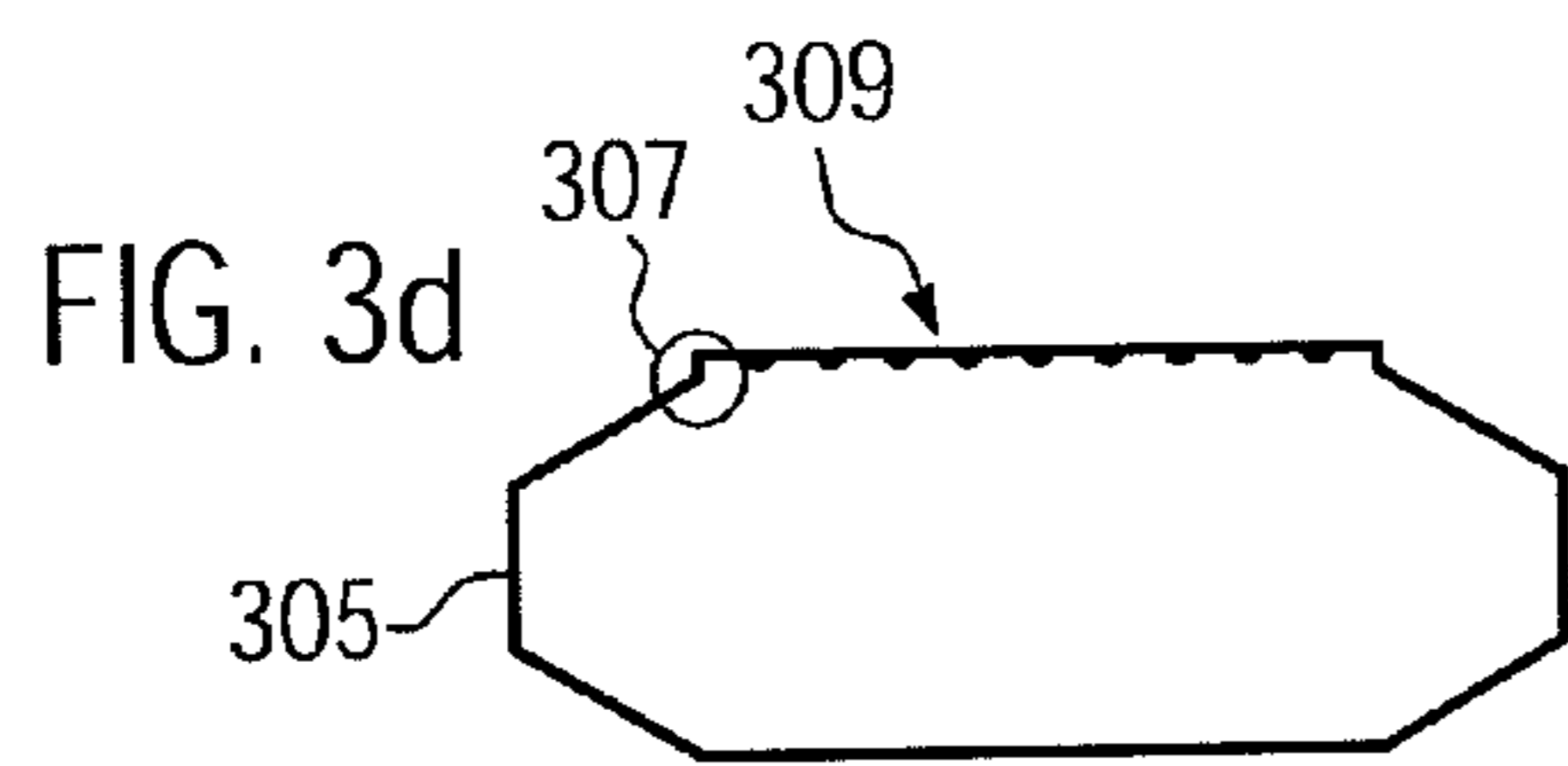
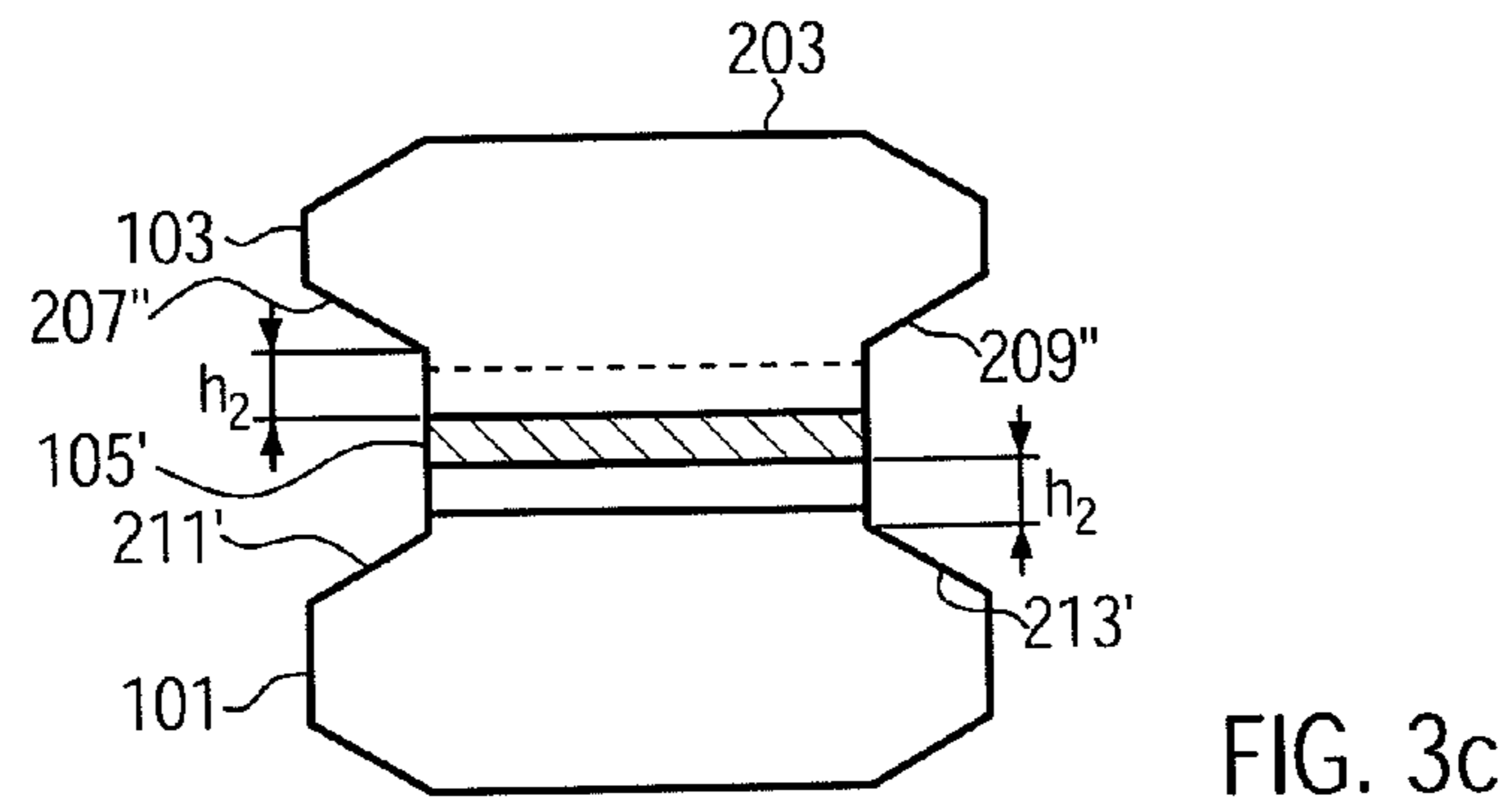
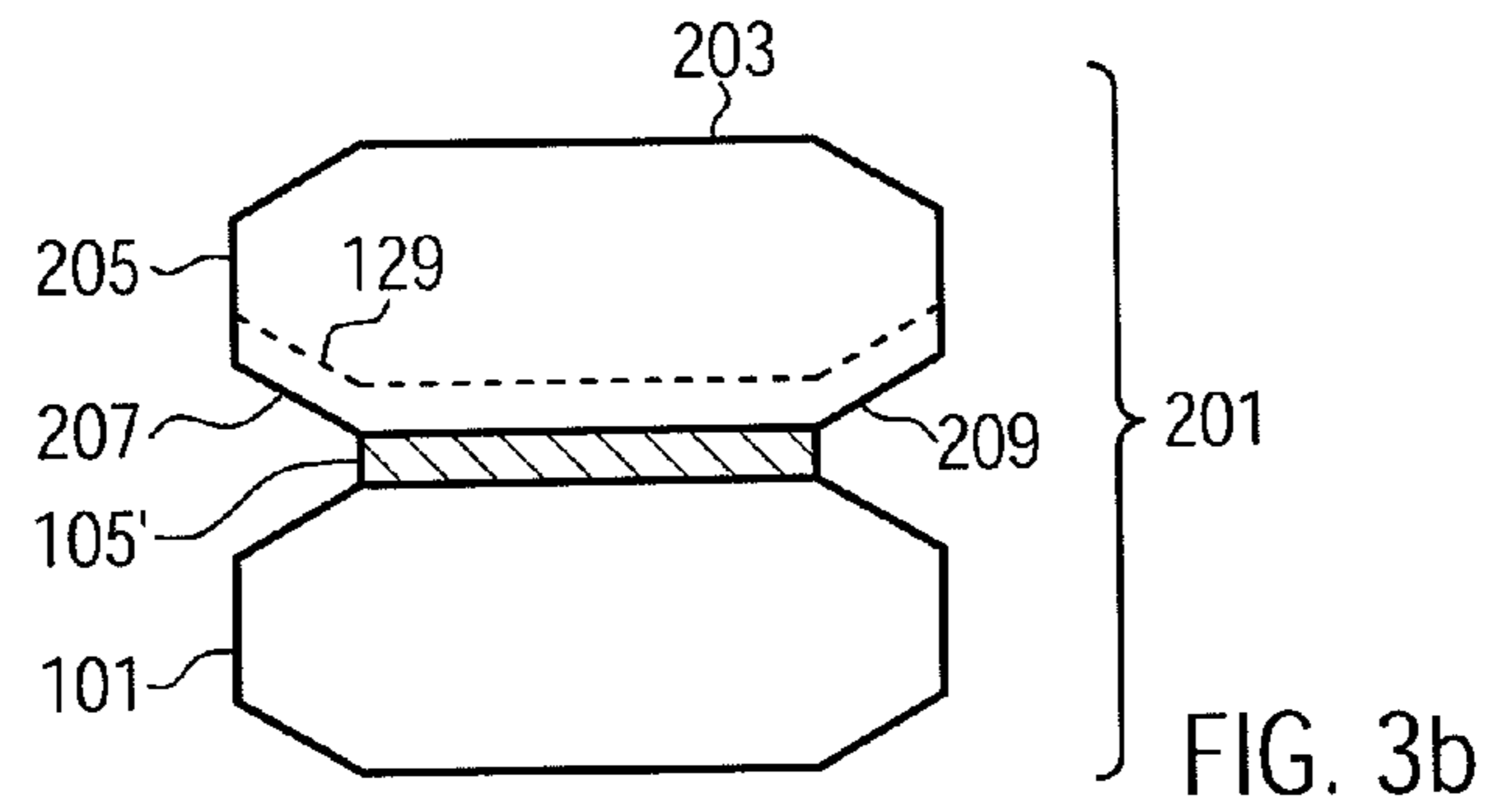
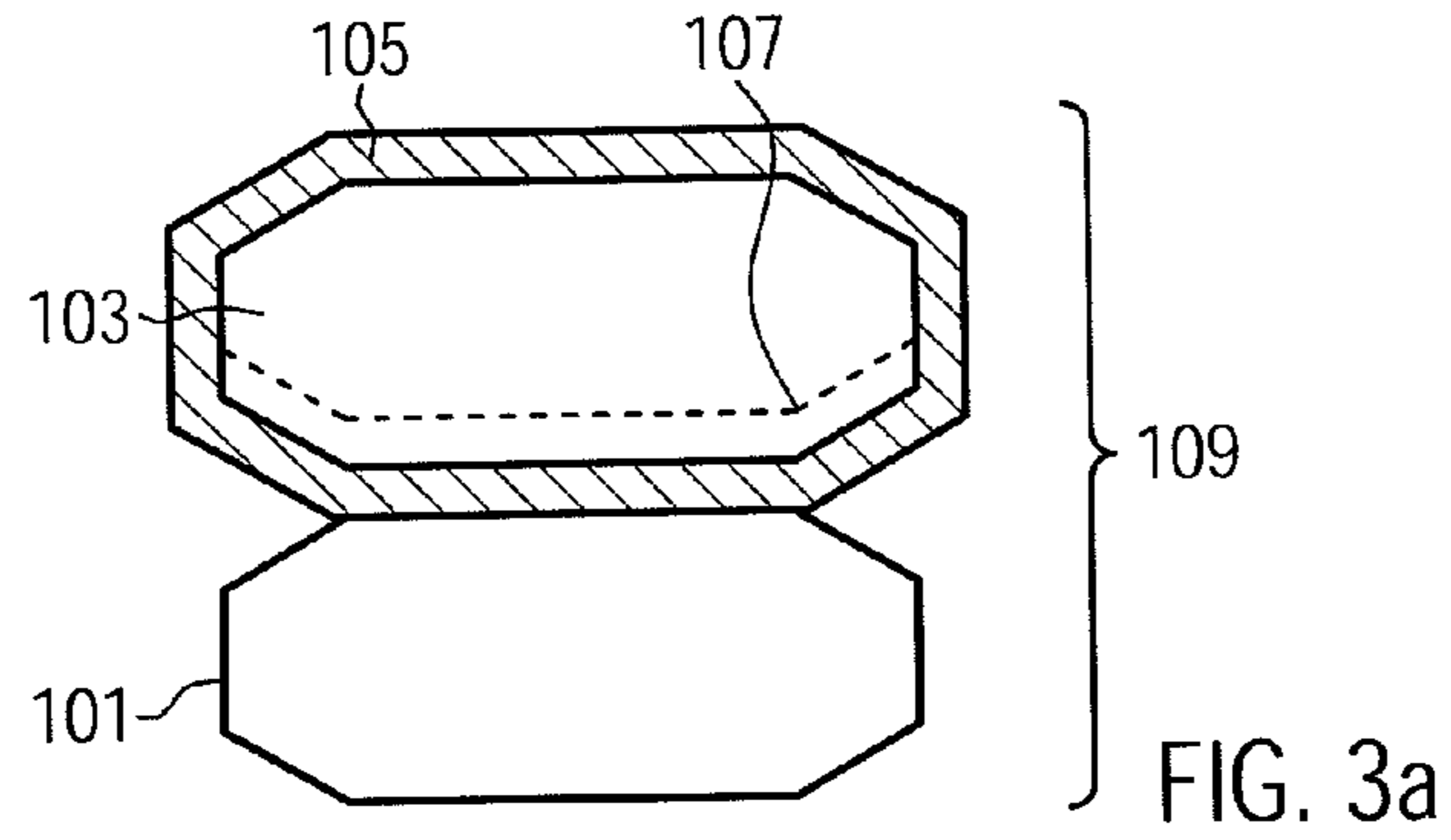
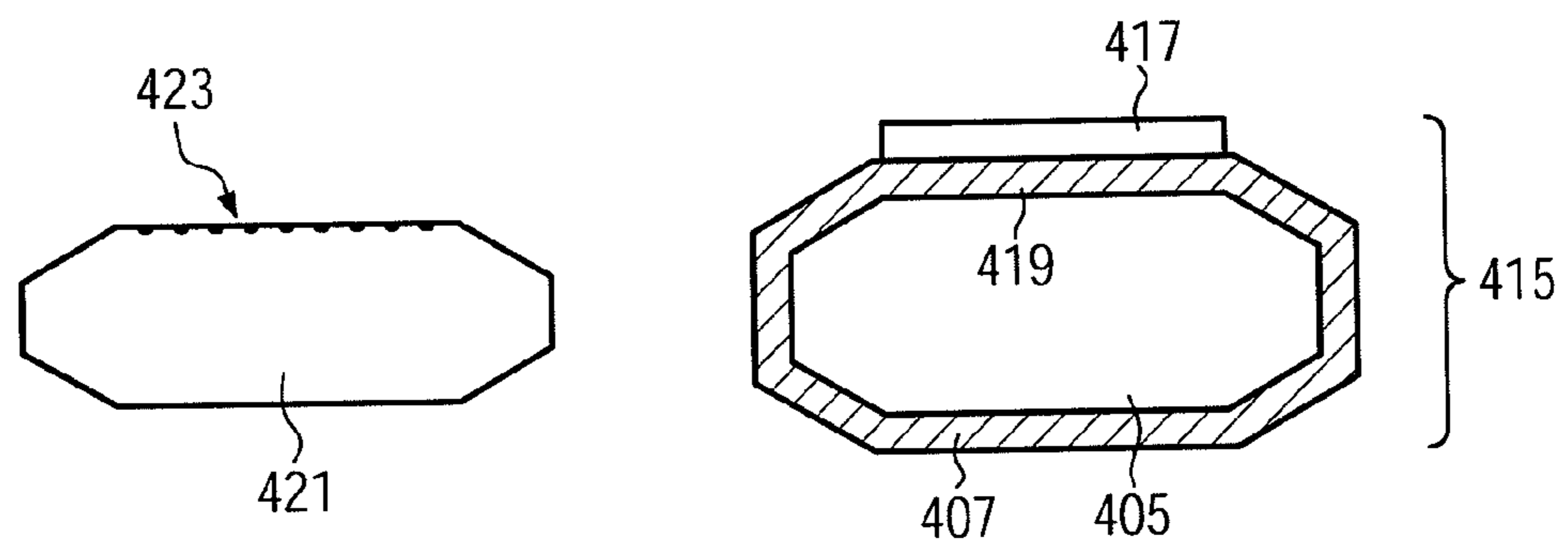
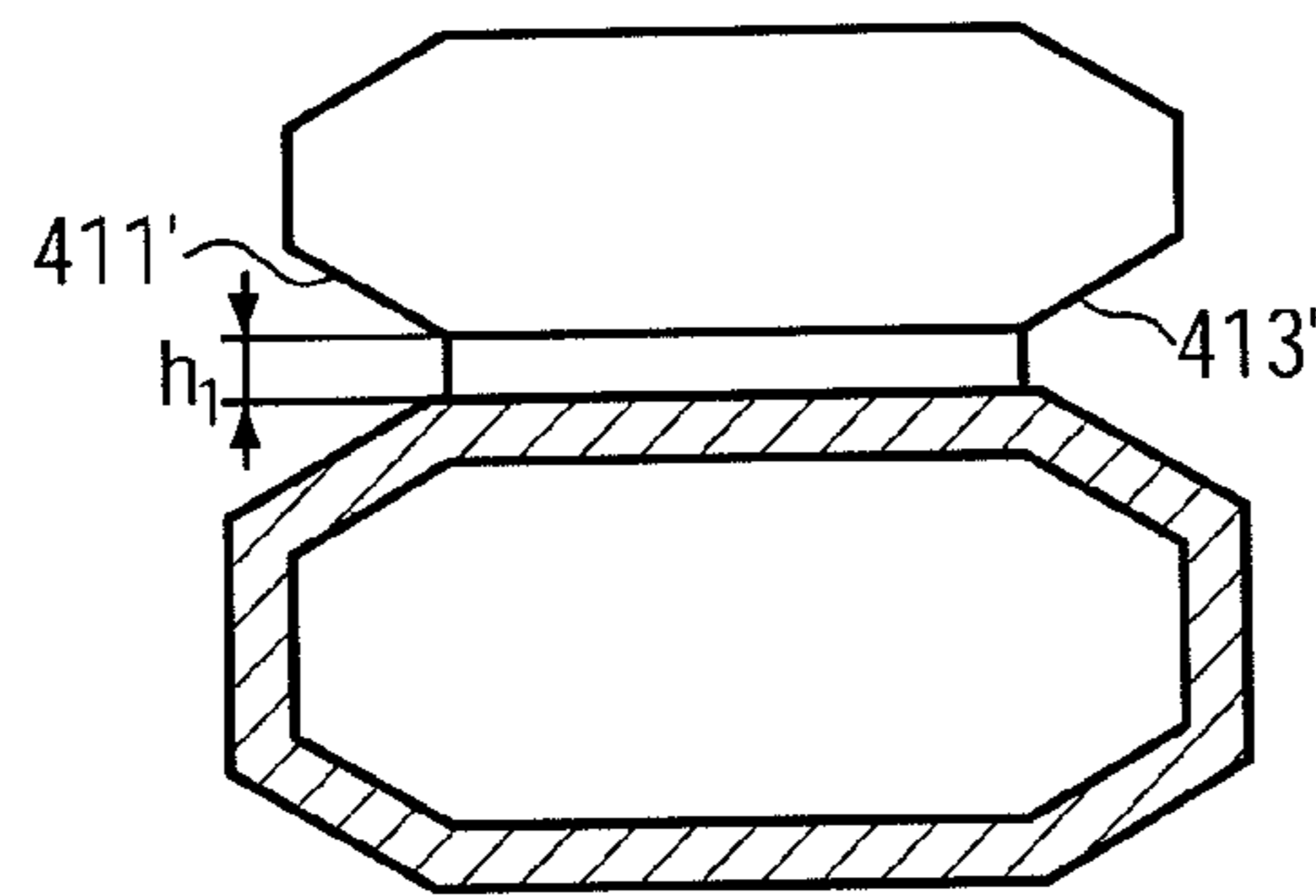
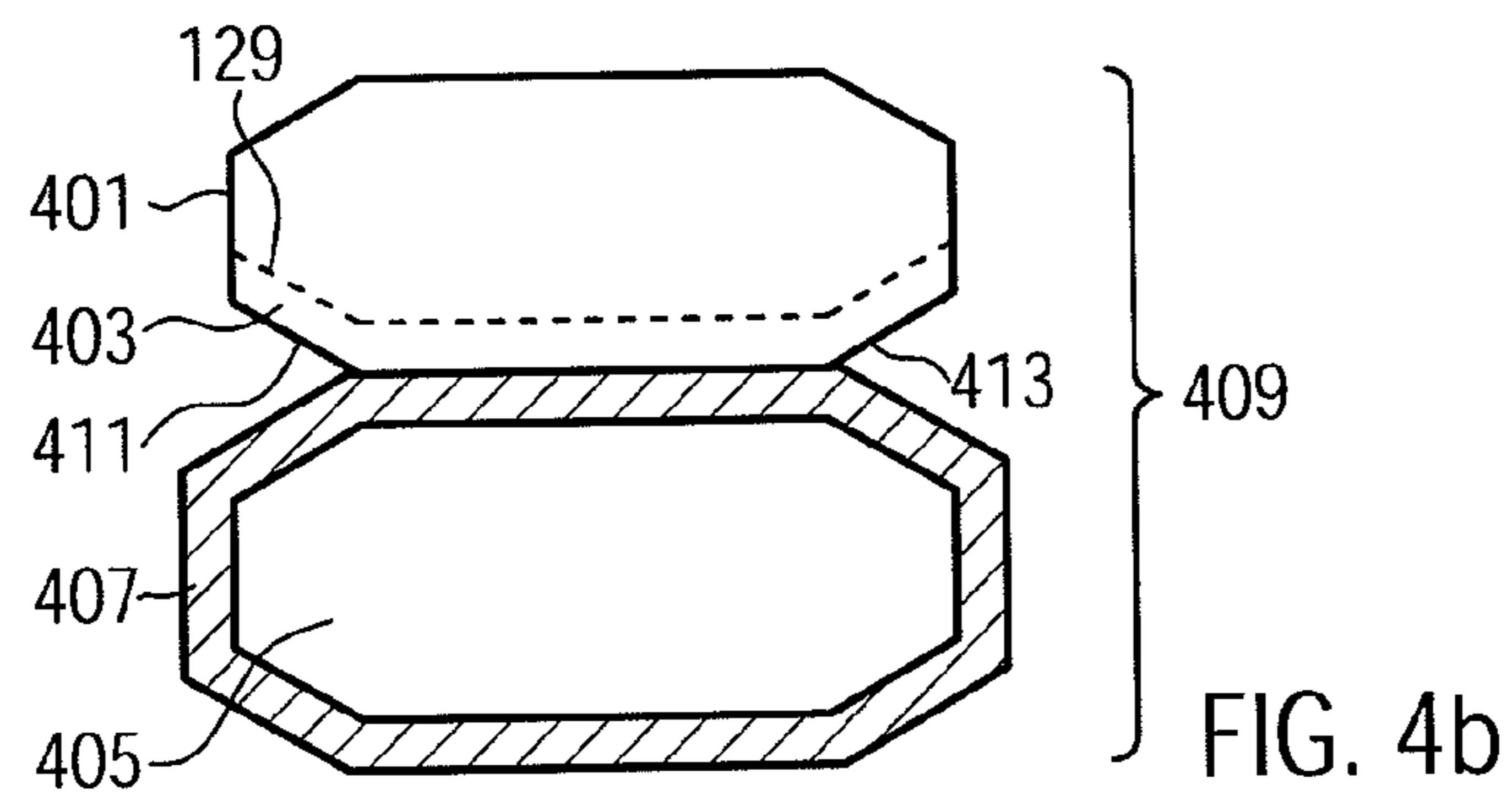
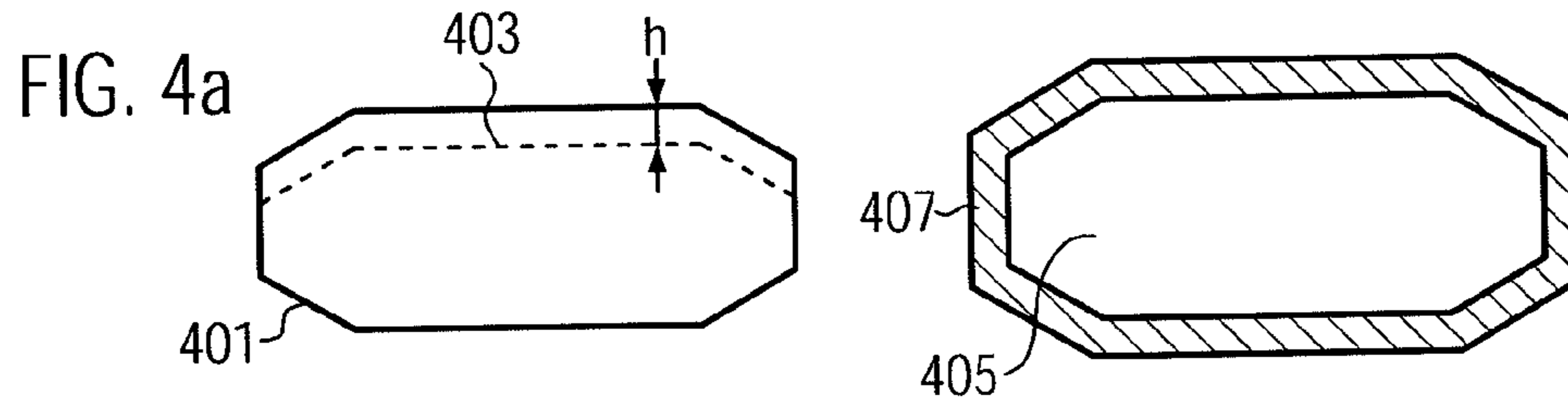


FIG. 1c







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## METHOD FOR TRANSFERRING A LAYER FROM A DONOR SUBSTRATE ONTO A HANDLE SUBSTRATE

### PRIORITY CLAIM

This application claims the benefit of the filing date of European Patent Application Serial No. EP09290314.5, filed Apr. 29, 2009, the entire disclosure of which is hereby incorporated herein by this reference.

### TECHNICAL FIELD

The invention relates to a method for transferring a layer from a donor substrate onto a handle substrate and for reclaiming the surface of the donor substrate for reuse.

### BACKGROUND

The so-called SMART CUT® process, illustrated in FIG. 1 provides high quality silicon on insulator (SOI) substrates. During this process (FIG. 1a), two substrates, called a handle substrate 101 and a donor substrate 103, usually Silicon wafers, undergo a certain number of process steps to transfer a layer with a given thickness of the donor substrate 103 onto the handle substrate 101. During the process, the donor substrate 103 is typically oxidized 105 to later on form the buried oxide layer (BOX) of the SOI structure, and an ion implantation step, during which ions like hydrogen or rare gas ions (He, Ar, . . . ) are implanted into the donor substrate 103, is applied to form a predetermined splitting area 107 defining the to-be-transferred layer. Subsequently (FIG. 1b), the source substrate 103 is attached to the handle substrate 101, in particular via bonding taking advantage of Van der Waal's forces, to obtain a source-handle compound 109. Upon a mechanical and/or thermal treatment, a detachment of a semiconductor layer 111 together with a buried oxide layer 113 occurs at the predetermined splitting area 107 so that the two layers are transferred onto the handle substrate 101 to obtain the desired silicon on insulator structure 115 (FIG. 1c). The thickness of the layer 111 is determined by the energy of the implanted ions.

The remaining part 117 of the donor substrate 101, also called the negative, can be recycled and again used in the SMART CUT™ type process as a new donor or handle substrate. The SMART CUT™ type SOI fabrication process has a significant economic advantage due to this recycling process. Indeed, the process provides an optimized use of the raw material for instance silicon wafers.

The negative 117 (FIG. 1c) has a characteristic topography representing protruding residues 119a and 119b in an edge region, as illustrated in FIG. 1, which corresponds to a region where no layer transfer occurred due to the chamfered shape of the edge of the initial wafers 103 and/or 101. The surface of the negative 117 between the protruding residues 119a and 119b has a first inner region 121 at which detachment occurred to provide the transferred layer 111 on the handle substrate 109 and which has a rather rough surface typically close to 60 Å to 70 Å RMS as measured by atomic force microscopy (AFM), which is to be compared to 1 Å to 3 Å for standard Silicon wafer. The edge of the remainder 117 with the protruding residues 119a and 119b actually has a chamfered shape and furthermore comprises a step-like structure 123 seen from the internal region 121 comprising the remaining part of the buried oxide layer 125 and the non-transferred silicon 127 over the remaining part of the ion implanted

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predetermined splitting area 129. The edge 131 and the backside 133 of the negative 117 are, also covered by the oxide.

The step 123 of the negative 117 typically has a thickness of about 100 Å to 10,000 Å of silicon, mostly between 1000 Å to 3000 Å, and 100 Å to 10,000 Å of silicon oxide and has a width w in the lateral direction of the order of 0.5 mm to 3 mm.

Prior to the reuse of the negative 117 as donor substrate 103 or handle substrate 101, the surface roughness of the inner region 121 needs to be reduced and the protruding residual topography 119a and 119b needs to be removed. The removal needs to be complete as any remaining protruding material can create particle contamination when during a thermal treatment an exfoliation in the chamfered region occurs due to the presence of the remaining ion implanted region 129. Methods to do so are, for example, known from EP 1 156 531 A1 and U.S. Pat. No. 7,402,520 B2. Typically, the following process is applied to get rid of the protruding residual topography: The reclaiming process of negative 117 starts with a de-oxidation step to remove the oxide layer 125 on top of the protruding residual topography on the edge of the remainder 117 as well as on the side 131 and on its backside 133. The de-oxidation can, for example, be carried out using a HF bath, wherein the acid consumes the oxide layers 125, 131 and 133. Subsequently, a first polishing step of the edge region of substrate 1 is carried out to at least partially remove the protruding silicon part 127 on the edge. Then a double-sided polishing (DSP) step is carried out to improve the surface roughness in the interior region 121 but also to further remove the step 123 in the direction of the protruding residual topography 119a and 119b, but also to remove residues remaining from the ion implantation. Finally, to obtain a suitable surface roughness on the front surface of the remainder 117, a chemical mechanical polishing step (CMP) is carried out.

Even though, it is possible to obtain a recycled substrate with the described reclaiming process and which can be reused in the SMART CUT™ process, it is an object of the present invention to provide an improved and more economic reclaiming process that no longer needs the double-sided polishing step to reclaim the remainder of the donor substrate. Indeed, the DSP process step has the major disadvantage that, during polishing, up to 10 μm (5 μm on each side of the substrate) of material are removed to get rid of the protruding residual topography 119a and 119b.

This object is achieved with the method according to claim 1. Accordingly, the method comprises the steps of a) providing a donor substrate, in particular a semiconductor substrate, and a handle substrate each with chamfered edge regions, b) forming a predetermined splitting area at a depth h inside the donor substrate, c) attaching, in particular by bonding, the donor and the handle substrate to obtain a donor-handle compound, wherein no attaching occurs between the two substrates in the chamfered edge regions of the donor and handle substrates, then d) etching the chamfered region such that at least a layer of about the thickness h is removed from the donor substrate in the region where no attaching occurred, then e) detaching a remainder of the donor substrate from the donor handle substrate, wherein detachment occurs at the predetermined splitting area and f) reusing the remainder of the donor substrate, in particular after the surface treatment step. According to a preferred embodiment, during step d), a layer with a thickness of more than h is removed.

Thus, unlike in the process of the prior art, the remainder of the donor substrate will no longer present a protruding portion 119a, 119b as illustrated in FIG. 1, as the chamfered area where no attachment occurs between the two attached substrates is removed prior to the detachment. By the fact that, no

longer any protruding regions are present at the surface of the remainder of the donor substrate, there is no need for carrying out the edge removal step and the double-sided polishing step, which were mandatory in the prior art to get rid of the protruding portion. As a consequence, the reclaiming of the remainder of the donor substrate can be carried out in a much simpler way not needing expensive additional tools to carry out the edge polishing and the double-sided polishing process steps. At the same time, due to the suppression of the double-sided polishing step, the initial geometry of the donor substrates can be kept even if one donor substrate is used several times in a process as described above. In addition, due to the fact that the implanted region in the chamfered region is removed during step d), the quality of the obtained substrates is also improved as the risk of creation of particles during a raise in temperature leading to a partial removal of the chamfered region, can be reduced.

Preferably, the method can use a donor substrate comprising a dielectric layer and, in this case, can furthermore comprise a step g) carried out between steps c) and d) which consists in removing the dielectric from the donor substrate at least in the chamfered region but not in the attached region. Thus, even in the presence of a dielectric used to form a semiconductor on insulator substrate with the mentioned process, it is still possible to achieve the advantages of the method as, not only the chamfered region of the donor substrate itself but also of its dielectric layer, is removed prior to detaching.

It has to be pointed out that the removal step to remove the dielectric layer does not represent an additional step which has to be carried out. Indeed, in the prior art, the dielectric layer is also removed during reclaiming. Thus, compared to the prior art, step g) is simply moved from after detachment to prior to detachment.

According to a variant, the handle substrate can comprise a dielectric layer. In this case, the dielectric layer is provided by the handle substrate to form a semiconductor on insulator substrate. This variant has the advantage that one only has to remove the material of the substrate in step d) to achieve the advantages of the invention, as no additional dielectric layer is provided on the donor substrate. Thus, in this variant, less process steps are necessary compared to the variant which provides the dielectric via the donor substrate.

Advantageously, the dielectric layer can be an oxide, in particular a silicon oxide. This oxide layer can be provided either by a thermal process or by deposition. Advantageously, steps e) and/or g) can be a wet or dry etching step. This is a more economic material removal step than the edge polishing and double-sided polished step as used in the prior art.

Preferably, steps e) and g) can be performed using a non-selective and/or isotropic etching solution. Using the non-selective etching process, both the dielectric layer and the underlying part of the donor substrate, for instance a semiconductor material, can be removed in one step. By using an isotropic etching solution, the process is furthermore simplified as varying etching rates, depending on the crystallographic directions that are different in the chamfered region compared to the rest of the substrate, do not have to be taken into account. This simplifies the control of the process.

The dielectric material removal step, independent of whether the dielectric layer is removed from the donor and/or the handle substrate (in case a dielectric is also present on the handle substrate), does not have an impact on the quality of the buried dielectric layer as this one is sandwiched between donor and handle substrate.

Advantageously, during step d), a layer with a thickness of about 100 Å to 10,000 Å, in particular 1000 Å to 3000 Å, can

be removed in the non-attached region of the donor substrate. Compared to the double-sided polishing step mandatory in the prior art during which a large amount of material, namely in the order of 5 µm on each side, had to be removed to get rid of the protruding portions, the material removal in the process according to the invention can be less so that one donor substrate can be reused more often, for instance, more than ten times, compared to the prior art process. This is also made possible by the fact that the reclaimed donor substrate remains within the semi-standard concerning the substrate dimensions.

Preferably, steps d) and/or g) can be carried out at a temperature of less than 500° C., preferably at less than 350° C. Thus, the whole process until detachment is carried out at low temperature so that no detachment can occur in the non-attached regions which could lead to unwanted particle contamination of the final product.

According to a preferred embodiment, the surface treatment step can, at most, comprise a polishing step, in particular a CMP polishing and a cleaning step before and/or after the polishing step. Thus, compared to the prior art, a greatly simplified reclaiming process can be carried out. The polishing step is used to get the desired surface quality of the reclaimed remainder of the donor substrate, typically a mirror-polished quality, and the cleaning steps, as known in the art, make the reclaimed donor substrate ready for reuse. Thus, instead of a three-level reclaiming process: i) edge polishing, ii) double-sided polishing, iii) mirror polishing plus the various cleaning steps, the invention provides the possibility to carry out the reclaiming process with only one simple mirror polishing step.

In this context, the term "about the thickness h" relates to thickness that are such that the remainder can be planarized using only a CMP process. This means that a layer is removed in step d) of claim 1 that has a thickness of at least h minus about 50 nm. This would lead to a protruding region in the remainder of the donor substrate with a height of about 50 nm, which can be dealt with by a simple CMP polishing step.

Advantageously, during CMP polishing, a layer of less than 3 µm, preferably less than 1 µm, can be removed from the surface where detachment occurred. As mentioned above, this limited material removal brings the advantage that one donor substrate can be reused more often, in particular, more than ten times, in the layer transfer process.

Advantageous embodiments will be described in combination with the enclosed Figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1a through 1c illustrate a prior art layer transfer process according to the SMART CUT™ technology;

FIGS. 2a through 2d illustrate a first embodiment of the inventive method;

FIGS. 3a through 3e illustrate a second embodiment of the inventive method; and

FIGS. 4a through 4d illustrate a third embodiment of the inventive method.

#### DETAILED DESCRIPTION OF THE INVENTION

FIGS. 2a through 2d illustrate a first embodiment of the inventive method for transferring a layer from a donor substrate onto a handle substrate. FIG. 2a illustrates the source-handle compound 109, as already illustrated in FIG. 1b. This source-handle compound 109 has all the properties as already described above in the introduction and is, therefore, not described in detail again, but reference is made to FIG. 1.

It should nevertheless be mentioned that the handle substrate **101** can be any suitable handle substrate, in particular a silicon wafer, but also a glass or quartz-type substrate. The donor substrate **103** can be a semiconductor substrate, in particular one out of a silicon, a silicon carbide, a silicon germanium, a gallium nitride or a germanium substrate and the isolating dielectric layer **105** can be one out of silicon dioxide, silicon nitride, silicon oxynitride or  $\text{Al}_2\text{O}_3$ , etc.

In the following, the inventive method will be described, without being limited to this particular choice, to a handle substrate **101** being a silicon wafer, a donor substrate **103** being a silicon wafer and the dielectric layer **105** being a silicon dioxide.

FIG. **2b** illustrates the source-handle compound **201** obtained after an etching step during which the dielectric layer **105** has been removed from the back side **203**, the side **205** but also the chamfered regions **207** and **209** of the donor substrate **103**. A dielectric layer **105'** remains sandwiched between the donor substrate **103** and the handle substrate **101** and forms the future buried oxide layer.

In this embodiment, the material removal is achieved with an etching step. The etching can be a dry or a wet etching suitable to remove the dielectric oxide layer which typically has a thickness of up to 1000 nm, but typically has a thickness of 10 nm to 200 nm.

Subsequently, as illustrated in FIG. **2c**, an additional etching step is carried out to remove the silicon present in the chamfered region **207'** and **209'**. The etching step can again be a wet or dry etching and is preferably an isotropic etching for instance using a wet etch with  $\text{HF}/\text{HNO}_3$  or a dry etch using a plasma. According to a variant the dielectric etching and the semiconductor etching are carried out using the same process.

The etching is carried out such that material is removed from the chamfered region **207'** and **209'** at least of the donor substrate **103** and such that the removed layer has a thickness  $h_1$  corresponding to the depth  $h$  of the predetermined splitting area **107**. Typically, the material removal not only occurs in the chamfered region but also on the side and on the back side of the donor substrate **103** and also in the chamfered region **211** and **213** of the handle substrate **101**.

By doing so, the ion implanted region **129**, present in the chamfered part **207** and **209** illustrated in FIG. **2b**, of the donor substrate **103** is removed.

The next step consists in a detachment step, the result of which is illustrated in FIG. **2d** and which is carried out in the same way as described in the introduction, thus either using mechanical and/or thermal energy. After detachment a semiconductor on insulator, here silicon on insulator substrate **215**, as illustrated on the right hand side of FIG. **2d**, is obtained. This structure **215** comprises the handle substrate **101**, the transferred oxide layer **105'** and the transferred silicon layer **111** from the donor substrate **103**. Due to the etching process, the substrate **215** furthermore comprises a step-like shoulder **217** in the chamfered edge regions **211** and **213** of the handle substrate **101** which makes the geometry of semiconductor on insulator substrate **215** slightly different compared to the one illustrated in FIG. **1c**.

The effect of the inventive method is even more visible on the remainder **219** of the donor substrate **103** illustrated on the left hand side of FIG. **2d**. The remainder **219** of the donor substrate **103**, according to the invention, no longer has a protruding portion in its edge region which is in complete contrast to the structure **117** according to the prior art illustrated in the left hand side of FIG. **1c** in the prior art.

The surface part **221** where detachment occurred has a rather rough surface, with roughness values close to 60 Å to

70 Å like in the prior art. However, due to the fact that the protruding portion is not present, the surface roughness can be improved by a simple CMP polishing process during which less than 3 μm, preferably less than 1 μm, or even only about 50 nm, of material is removed from the surface to obtain the desired surface quality for reuse of the reclaimed remainder **219**.

The chemical/mechanical polishing step can be accompanied by standard cleaning processes as in the prior art.

Compared to the prior art, the method according to the first embodiment has the advantage that, after detachment, no protruding portions are present in the edge regions, which is in complete contrast with the prior art, see reference numerals **119a**, **119b** in FIG. **1**. As a consequence, the reclaiming process to recondition the remainder **219** of the donor substrate **103** such that it can be reused is greatly simplified. No edge polishing and no double-sided polishing are necessary and a simple CMP process is sufficient to obtain the desired surface quality properties, eventually accompanied by one or two cleaning steps. Thus, the recycling process is not only cheaper to carry, as less equipment is necessary for the process, but also one donor substrate can be reused more often. Whereas, typically 10 μm of material had to be removed in the prior art process, the inventive process can be carried out with a greatly reduced material removal of the order of less than 3 μm, typically 0.5 μm to 1 μm. It is even possible to carry out the reclaiming process by only removing about 50 nm from the surface **221**. Thus, one donor substrate **103** can be recycled more often than in the prior art, namely about at least 10 times. Due to the fact that no DSP is necessary, also the geometry of the initial substrate can be kept. Besides, another important advantage is, that the creation of particles during step e), i.e., thermal treatment leading to the detachment or any subsequent thermal treatment step can be prevented or at least reduced as, in the chamfered region, the remaining ion implanted part is removed so that it cannot explode away during a subsequent thermal treatment and thus the creation of undesired particles can be reduced or even prevented.

FIGS. **3a** through **3e** illustrate a second embodiment of the inventive method for transferring a layer of a donor substrate **103** onto a handle substrate **101**. FIG. **3a** again illustrates the source-handle compound **109**, the description thereof is not repeated again but incorporated herewith by reference to the description of FIG. **2a**. The same is valid for FIG. **3b**, illustrating the resulting structure **201** after the dielectric material removal step.

The difference between the first embodiment and the second embodiment is that, during the etching of the chamfered region **207''** and **209''** of the donor substrate **103**, the material removal goes beyond the depth of the predetermined splitting area **107**, **129**, as illustrated in FIG. **3c**, by reference numeral  $h_2$ . Again, the predetermined splitting area **107** is still present within the donor substrate **103**. As a consequence of the longer etching process, also the material removal in the chamfered region **211'** and **213'** of the handle substrate **101** is of the order of  $h_2$ .

Compared to the first embodiment, the additional material removal has the advantage that it is ensured that all implanted areas **129** present in the chamfered regions **207** and **209** are removed.

After the detachment step, the semiconductor on insulator substrate **301**, as illustrated on the right hand side of FIG. **2d**, is obtained that essentially corresponds to the one **215** illustrated on the right hand side of FIG. **2d**. However, the step-like region **303** at the transition between the chamfered region



211' and 213' and the buried oxide layer 105' is higher ( $h_2$ ) than in the semiconductor on insulator substrate 215 of FIG. 2d.

Unlike the remainder 217 illustrated in FIG. 2d, the remainder of the donor substrate 305 in this embodiment also has a step-like shoulder 307 with a step height  $h_2$ . However, like in the first embodiment, the surface 309 at which detachment occurred still carries defects due to the ion implantation and thus needs to be polished. In the second embodiment, the polishing step is carried out such that the step-like structure 307 is removed so that a ready to reuse donor substrate 311, as illustrated in FIG. 3e, is obtained. This substrate 311 is again flat, except for the chamfered region, which is like the original substrate 103, except for a reduced thickness.

With the second embodiment, the same advantages as can be achieved like with the first embodiment.

According to a variant of the invention, instead of providing a semiconductor on insulator substrate, the process could be carried out without an intervening dielectric layer, which is called a direct silicon bonding process. In this case, the first and second embodiments could be carried out without the step of removing the dielectric layer 105, as illustrated in FIGS. 2b and 3b.

FIGS. 4a through 4d illustrate a third embodiment of the invention. This embodiment is slightly different compared to the first and second embodiments as, here, the dielectric layer is provided on the handle substrate side and the donor substrate is a bare semiconductor wafer, for instance a silicon wafer. The materials that can be used in this embodiment correspond to the ones of the first and second embodiment.

The left side of FIG. 4a illustrates the donor substrate 401 with a predetermined splitting area 403 and the right side the handle substrate 405, which in this case also comprises a dielectric layer 407, for instance silicon oxide.

FIG. 4b illustrates a handle compound 409 achieved by bonding the donor and the handle substrate 401 and 405. Like in the first and second embodiments on the surface side where bonding occurred, a non-attached region 411 and 413 can be observed which is due to the chamfered edge region of both substrates.

Subsequently, and as illustrated in FIG. 4c, an etching step is carried out to remove a layer of thickness  $h_1$  corresponding to the depth  $h$  of the predetermined splitting area 403 is removed in the non-attached edge regions 411' and 413'. Thus like in the first and second embodiment, the ion implanted region 129 in the edge region of the donor substrate 401 is removed by this step. As the donor substrate 401 is not covered by the dielectric layer, which is in contrast to the first and second embodiment, no oxide removal step is necessary in this embodiment.

After detachment, achieved by a thermal and/or mechanical treatment, a SOI substrate 415 is obtained comprising a transferred layer 417 and a buried oxide layer 419 still part of the original dielectric layer 407 covering the handle substrate 405. Eventually a deoxidation step could be carried out to remove the dielectric layer 407 except for the buried part 415 to obtain a SOI substrate as illustrated in FIG. 2d or 3d.

The remainder 421 of the original donor substrate 401 has the same structure than the one illustrated in FIG. 2d. A simple CMP polishing process is sufficient to remove the defects on the surface 423 where detachment occurred.

Finally, according to a variant, the material removal step illustrated in FIG. 4c, could also be carried out such that a thickness  $h_2$  is removed which is larger than the depth  $h$  of the predetermined splitting area 403, just like in the second embodiment.

According to a variant the first through third embodiments can also be carried out without the presence of a buried oxide dielectric layer 105'. In the so-called direct silicon bonding technology, two Si wafers, typically one with a 100 and the other one with a 110 surface, are bonded together. In this case, the process described are carried out in the same way without, however, the step of removing the oxide by etching. It should furthermore be mentioned that by CMP a remaining protruding portion of about 50 nm, which could be present in the edge region in case the material removal did not go up until  $h$  or beyond, can still be removed.

In the following practical examples according to the invention will be described.

Example One, according to the invention: a Silicon on Insulator substrate with a buried thermal oxide of thickness 145 nm and a transferred layer of thickness 250 nm is achieved using an etching process of the source handle substrate as illustrated in FIG. 2b. In this example the oxide is etched using HF and then the Si is etched using HF/HNO<sub>3</sub> such that  $h_1 = h = 250 \text{ nm} \pm 5\%$ . The remainder of the donor substrate is recycled using a CMP process removing a layer with thickness of 0.5  $\mu\text{m}$ . In this example a two step selective etching is carried out: first the HF removes the oxide but does not etch Si, and the second bath using HF/HNO<sub>3</sub> eventually buffered using CH<sub>3</sub>COOH acid etches the silicon.

Example Two, according to the invention: a Silicon on Insulator substrate with a buried thermal oxide of thickness 145 nm and a transferred layer of thickness 300 nm is achieved using an etching process with HF/H<sub>2</sub>O<sub>2</sub>/H<sub>2</sub>O and  $h_1 = 250 \text{ nm}$ , with  $h$  being 300 nm. The recycling of the remainder is carried out by an EP and CMP step. In this example the HF/H<sub>2</sub>O<sub>2</sub> bath is not selective and both layers the oxide and the silicon can be etched in one step. Edge polishing is performed to get rid of any potential residue of the implanted layer on the edge since material removal did not go up until  $h$  or beyond ( $h_1 \sim h - 50 \text{ nm}$ ), but the remaining 50 nm can also be removed with a CMP step and no EP polishing.

Example Three, according to the invention: a silicon on insulator substrate with a buried thermal oxide of 10 nm thickness and a transferred layer of 250 nm is achieved using a plasma (dry) etch such that  $h_1 = h = 250 \text{ nm} \pm 5\%$ . During the dry etch, a first plasma based on CF<sub>4</sub> or CHF<sub>3</sub> etches the oxide and then a second plasma on the basis of SF<sub>6</sub> etches the silicon. In this case one of the two substrates, preferably the donor substrate, has one of its main surfaces, called the back surface, on a substrate holder which prevents etching of the back side. In this case the reclaiming of the remainder of the donor substrate comprises an additional deoxidation step to remove the oxide from the back side plus the CMP step polishing the front surface and removing about 1  $\mu\text{m}$  of Silicon.

Example Four, according to the invention: a Silicon on Insulator substrate with a 145 nm buried insulator layer comprising SiO<sub>x</sub>N<sub>y</sub> and one or more SiO<sub>2</sub> layers, etched using HF and H<sub>3</sub>PO<sub>4</sub> and then HF/HNO<sub>3</sub> such that  $h_1 = h = 250 \text{ nm} \pm 5\%$ .

What is claimed is:

1. A method of transferring a layer from a donor substrate onto a handle substrate and for reclaiming a surface of the donor substrate for reuse, comprising:
  - providing a semiconductor donor substrate and a handle substrate each comprising a chamfered edge region;
  - forming a predetermined splitting area at a depth inside the donor substrate;
  - bonding the donor substrate and the handle substrate to obtain a donor-handle compound structure, wherein no bonding occurs between the donor substrate and the

handle substrate in the chamfered edge regions of the donor substrate and the handle substrate;  
 after bonding the donor substrate and the handle substrate, performing an isotropic etching process on the donor substrate and removing a layer of the donor substrate from the chamfered region of the donor substrate having a thickness of at least about the depth at which the splitting area is formed inside the donor substrate, the removed layer of the donor substrate including a portion of the predetermined splitting area in the chamfered edge region of the donor substrate;  
 after performing the isotropic etching process on the donor substrate, detaching a remainder of the etched donor substrate from the donor-handle compound structure at the predetermined splitting area;  
 treating a surface of the remainder of the etched donor substrate; and  
 reusing the remainder of the etched donor substrate.

**2.** The method of claim **1**, wherein the donor substrate comprises a dielectric layer, and wherein the method further comprises, prior to performing the isotropic etching process on the donor substrate, removing the dielectric layer from the donor substrate at least in the chamfered edge region of the donor substrate but not in a region of the donor substrate bonded to the handle substrate after bonding the donor substrate and the handle substrate.

**3.** The method of claim **2**, wherein the dielectric layer of the donor substrate comprises an oxide.

**4.** The method of claim **3**, wherein the dielectric layer comprises silicon oxide.

**5.** The method of claim **2**, wherein removing the dielectric layer from the donor substrate at least in the chamfered edge region of the donor substrate comprises etching the donor-handle compound structure using at least one of a wet etching process and a dry etching process.

**6.** The method of claim **5**, wherein etching the donor-handle compound structure using the at least one of the wet etching process and the dry etching process comprises using at least one of a non-selective etching solution and an isotropic etching solution.

**7.** The method of claim **5**, wherein etching the donor-handle compound structure using the at least one of the wet etching process and the dry etching process comprises etching the donor-handle compound structure at a temperature of less than about 500° C.

**8.** The method of claim **1**, wherein the handle substrate comprises a dielectric layer.

**9.** The method of claim **1**, wherein performing the isotropic etching process on the donor substrate comprises using at least one of a wet etching process and a dry etching process to isotropically etch the donor substrate.

**10.** The method of claim **9**, wherein using the at least one of the wet etching process and the dry etching process to isotropically etch the donor substrate comprises using at least one of a non-selective etching solution and an isotropic etching solution.

**11.** The method of claim **1**, wherein performing the isotropic etching process on the donor substrate and removing the layer from the donor substrate comprises removing a layer from the donor substrate having a thickness of about 100 Å to about 10,000 Å in the chamfered edge region of the donor substrate.

**12.** The method of claim **11**, wherein performing the isotropic etching process on the donor substrate and removing

the layer from the donor substrate comprises removing a layer from the donor substrate having a thickness of about 1,000 Å to about 3,000 Å in the chamfered edge region of the donor substrate.

**13.** The method of claim **1**, wherein performing the isotropic etching process on the donor substrate comprises isotropically etching the donor substrate at a temperature of less than about 500° C.

**14.** The method of claim **13**, wherein performing the isotropic etching process on the donor substrate and removing the layer from the donor substrate comprises isotropically etching the donor substrate at a temperature of less than about 350° C.

**15.** The method of claim **1**, wherein treating the surface of the remainder of the etched donor substrate at most comprises a polishing process and a cleaning process performed at least one of before and after the polishing process.

**16.** The method of claim **15**, wherein treating the surface of the remainder of the etched donor substrate comprises chemically and mechanically polishing the surface of the remainder of the etched donor substrate and removing a layer having a thickness of less than 3 μm from the surface of the remainder of the etched donor substrate.

**17.** The method of claim **16**, wherein treating the surface of the remainder of the etched donor substrate comprises chemically and mechanically polishing the surface of the remainder of the etched donor substrate and removing a layer having a thickness of less than 1 μm from the surface of the remainder of the etched donor substrate.

**18.** A method of transferring a layer from a donor substrate onto a handle substrate and for reclaiming a surface of the donor substrate for reuse, comprising:

providing a semiconductor donor substrate and a handle substrate, at least the donor substrate comprising a chamfered edge region;

forming a predetermined splitting area at an average first depth inside the donor substrate;

bonding the donor substrate and the handle substrate without bonding the chamfered edge region of the donor substrate to the handle substrate;

while the donor substrate remains bonded to the handle substrate, isotropically etching at least one exposed surface of the donor substrate and removing material from the at least one exposed surface of the donor substrate to an average second depth that is greater than the average first depth and removing a portion of the predetermined splitting area in the chamfered edge region of the donor substrate; and

detaching the etched donor substrate from the handle substrate at the predetermined splitting area after isotropically etching the at least one exposed surface of the donor substrate and transferring a portion of the donor substrate to the handle substrate.

**19.** The method of claim **18**, further comprising transferring an additional portion of the donor substrate to another handle substrate after detaching the etched donor substrate from the handle substrate at the predetermined splitting area and transferring a portion of the donor substrate to the handle substrate.

**20.** The method of claim **18**, further comprising smoothing a surface of the donor substrate after detaching the etched donor substrate from the handle substrate at the predetermined splitting area.